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6 J. C. Houzeau

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WHAT DOES ZODIACAL LIGHT CONSIST OF?

J. C. Houzeau

ABSTRACT. Various hypotheses of the nature of zodiacal light and its relationship to gegenschein are discussed. Theoretical conditions attempting to compare it to comas or tails of comets are considered.

In the two preceding issues we described the general appearances of zodiacal light and showed that the faint light which constitutes it is spread out along the orbital plane in which the Earth revolves around the Sun. The matter from which these faint lights come to us is therefore situated in or near this plane. It accompanies the Earth in its annual revolution and is extended, as is proved by the existence of gegenschein, along the radius vector of our planet, i.e., along the straight line leading from the Sun to the Earth and carried along in the latter's motion. /517*

Now there is only one thing, says Brorsen, which is thus linked to the extension of the radius vector: that is comet tails (ref. 1). This idea, very briefly expressed in 1859 by the German astronomer, has until now passed almost unnoticed. However, the more the appearance of zodiacal light is considered, the more the analogies between this phenomenon and comet tails takes hold. Therefore, it will not be out of place to examine this hypothesis more closely. Might the existence of an emanation, repelled by the Sun, be more general than has hitherto been thought, and would it manifest itself to a slight degree for our globe and perhaps for other planets as well, as well as it is shown in comets? /518

Venus and the Moon, for example, have been seen to be accompanied under certain circumstances by projections of light which had a median plane comparable to that of their orbit, and in certain respects had the appearance of tails or comas of comets. Such were the shiny rays which Beer and Mädler noticed one day emanating from Venus and increasing (ref. 2). Such also were the luminous emanations attached to the lunar disk observed several times by Holden and named by him lunar zodiacal light (ref. 3). It is true that one might ask why these appearances are visible only in special cases. We do not intend to discuss this objection; however, we will point out that comet tails undergo unexplainable changes in brilliance and that zodiacal light weakens and increases again with no apparent cause at intervals of sometimes several days. The variable intensity of these lights might explain how the most difficult to distinguish disappear easily and are noticed only in cases of maximum brilliance.

But let us return to the Earth and consider the appearances which a comet-like coma and tail of very low intensity accompanying our globe would offer its inhabitants.

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Numbers in the margin indicate original pagination in the foreign text.

The emanation is produced principally by the portion of the heavenly body turned from the Sun and then extends along the sides, spreading in tubular form along the extension of the radius vector. From the Sun this emanation forms jets which rise, curve and, spreading out, sometimes cover one another. The comet of Coggia, so often and so capably drawn and even photographed by several astronomers, presented this arrangement in a striking manner. The coma was as if composed of several curved and variously extended scales or, if you will, more-or-less im- 519 bricate petals. The heavenly body seemed to remain in the midst of the corolla of a flower. The emanation escaped in enveloping nappes which were directed some to the right, others to the left of the nucleus, to supply the tail. From this the stratified appearance of the coma.

Now, if we were placed in the comet's nucleus, we would not be able to distinguish the coma itself, which would project on an illuminated sky. We would only see the end of these envelopes, beginning with the inception of the tail. And there the appearances would be those of our zodiacal light. The imbricate leaves would form the layers which constitute this light: first the loosest and least luminous envelope: the "diffuse light" of Jones or the mantel of Heis; then the concentric layers; finally in the center the densest and most luminous jet: the "stronger light" of Jones or the Kern (nucleus) of the German observers.

The brilliance of comet tails diminishes proportional to the degree the emanation reaches to the extension of the radius vector. This is the effect produced also in zodiacal light, whose spindles attenuate in relation to the distance from the Sun. However, as brilliance diminishes in the direction of the length, they remain exactly in the orbital plane. This is a characteristic trait of comets. Not only does there exist in this regard the opinion of the ancients: *cometarum caudae Solis radios effugiunt* (comet tails flee the rays of the Sun) as well as the categorical affirmation of Apian so often quoted, but there are also the calculations of Brandes and the recent and authoritative discussion of Bredichin, who concludes one of his interesting studies on the composition of comets with an aphorism: "Phenomena in the tail develop in the orbital plane (*Les phenomenes de la queue se developpent dans le plan de l'orbite*)."

And so, let us follow in the Earth's orbital plane the two bands which extend from the two sides of our globe like two rollers on a pulley and are located parallel to the extension of the radius vector. At the spot where these two bands or strips terminate, zodiacal light proper, i.e., the spindles from the 520 East and West, is extinguished. And if these strips take on the appearance of spindles in our eyes, it is an effect of perspective, since the neighboring part of the horizon is much closer to us and must appear much larger than the distant end.

However, there exists a vague light in comet tails between the two strips or rims which serves as a tie. This is the very body of the tail itself, much less brilliant than its edges. How should this intermediate material appear? In the form of a "bridge" which unites the lateral sheathes. We must not imagine that this bridge is a thin lace in the sky. We should refer especially to the observations made of it by Schiaparelli (3 May 1862), Eylert (8 and 9 December 1873), and Serpieri (12 December 1873). It will be seen that this light achieves a width of a dozen degrees and almost matches in size the smaller vertical side of the square of Orion.

Let us note in addition that from the portion of our globe in opposition to the Sun, at midnight for example, the visible ray crosses a length as much greater than the tail as it is less inclined on the radius vector. In looking directly opposite the Sun, the eye probes the diffuse matter of the tail and follows its greatest length, and it is in fact here that the maximum of light, the gegenschein, is observed. The view becomes more oblique in proportion to how far the observer moves from this point and catches the tail slantwise: the brilliance should be weaker, which observation in fact verifies.

For the rest, there is another reason for the weak brightness of the section between the edges, which is that it is located in the Earth's umbra and can be perceived only by its own light. Now, experience proves that the spindles from the zodiacal light, if they spontaneously emit a little light, nevertheless shine in large part from the glow which the Sun diffuses on the molecules of the emanation. This is what the spectrum and polarization attest to at the same time. Their spectrum is that of the Sun, diffuse and weakened. Polarization of their rays occurs in a plane passing by this heavenly body. Whence Arthur Wright concludes that zodiacal light is composed of solid corpuscles which attract from the Sun at least the major part of the brilliance with which they /521 shine (ref. 4).

It must be granted that the appearances are represented in a remarkable way by this hypothesis. We are quite far from the old explanation which supposed a cloud of matter around the Sun. The phenomenon of zodiacal light merits all the attention of astronomers, and no doubt holds a surprise in store for us. In studying these celestial lights, it is no longer a matter of redoing what has been attained; the attention of observers must proceed to the new points to clarify. As an example I will cite the relative remoteness of the different parts of the zodiacal light. If we were to succeed in ascertaining, either by effects of parallax or by other means, that the feet of the bright pyramids are nearer than their summits or if the ratio of these distances was to be determined, the theory of zodiacal light would have made a great advance. If, on the other hand, photometric measurements permitted establishing the thickness of the luminous matter which we have before us in the various parts of the "bridge" and of the "gegenschein," what results might not come from these observations?

We are in the presence of a phenomenon which has remained a vague enigma for two centuries. But the day is starting to dawn, and the word by Brorsen in 1859 has perhaps put us on a path which need only be followed to bear fruit.

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